Values in Science and in Science Education

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Abstract

We call values that which founds a judgment (good or bad, important or not, right or wrong, true or false, beautiful or ugly, expensive or cheap, …). After giving some definitions, this paper analyzes the values that are identifiable inside science, and then inside science education.

The value of science comes from its economical and political importance, but science seeks the truth by observing important values: a scientist must be honest, modest, always critical, rejecting any dogmatism and any fraud, but also creative, imaginative and able to work collectively. Nevertheless, a scientist is a human being with emotions and ideologies often interfering with his/her work and results. Some examples are discussed. Science must be separated from religion but the values of science and those of ethics overlap (bio-ethics, citizen values).

UNESCO promotes Education for All, even if there are still important inequalities among countries. The values of science education are analyzed, and developed furtheron the example of ESD (Education for a Sustainable Development). They are then analyzed in some images of science textbooks, showing implicit ideologies linked to the scientific messages. They are also identified through different pedagogical styles.
The analysis of teachers' conceptions, through an international survey covering more than 8 000 teachers, reveals deep differences among countries, as well as opposite systems of values, in interaction with social practices and actual or out-dated scientific knowledge, illustrating the KVP model as is also the case throughout this paper.

Key-Words – Science – Science Education - Values – Scientific knowledge – Social Practices – KVP Model – Ideologies – Teachers – Science in Society - STS -

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L'Education scientifique et technique
pour le Développement, la Citoyenneté et la Justice sociale

Les Valeurs dans la Science et dans l'Education scientifique

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Résumé
Nous appelons 'valeurs' tout ce qui fonde le jugement (vrai ou faux, beau ou laid, bon ou mauvais, important ou non, cher ou bon marché, …). Après avoir donné quelques définitions, nous analysons les valeurs identifiables au sein même de la science, et ensuite au sein de l'éducation scientifique.

La science est valorisée, financée, à cause de ses enjeux économiques et politiques, mais ce qui la caractérise est qu'elle cherche à atteindre des vérités en respectant des valeurs importantes : un scientifique doit être honnête, modeste, toujours critique, il doit rejeter tout dogmatisme et toute fraude, mais il doit aussi être créatif, imaginatif et savoir travailler collectivement. Cependant, tout scientifique est un être humain dont les idéologies et émotions interfèrent souvent avec son travail et ses résultats. Plusieurs exemples sont présentés. La science doit être séparée de la religion mais les valeurs de la science et celles de la morale, de l'éthique, se superposent en partie (bio-éthique, valeurs citoyennes).

L'UNESCO promeut 'l'Education pour Tous', alors qu'il y a encore de profondes inégalités entre pays. Les valeurs de l'éducation scientifique sont analysées, en particulier sur l'exemple de l'EDD (Education au Développement Durable). Sont ensuite analysés quelques manuels scolaires de sciences, mettant en évidence des implicites idéologiques liés à des messages scientifiques : à travers des images, comme à travers le style pédagogique. L'analyse des conceptions d'enseignants, effectuée grâce à une enquête internationale sur plus de 8 000 enseignants, révèle de fortes différences entre pays, ainsi que des systèmes de valeurs opposés, qui sont en interaction avec des pratiques sociales et avec des connaissances scientifiques dépassées ou actualisées : ce qui illustre le modèle KVP, comme l'ont aussi fait toutes les parties de ce texte.

Mots-clés
– Science –Education scientifique - Valeurs – Connaissance scientifique –Pratiques sociales – Modèle KVP – Idéologies – Enseignants – Science dans la Société - STS -

1 – Definition of values

Values guide individual and social actions. For this reason, regular surveys have been undertaken to identify values in different countries around the world, particularly in Europe (Ronald Inglehart et al., 2000 - World values surveys and European values surveys, 1981-1984, 1990-1993, and1995-1997: ICPSR 2790). These surveys have shown a great stability of answers over time in each country, with nevertheless some evolution. The latest surveys were carried out in 1999 and in 2008 (Bréchon & Tchernia, 2009). Nine domains of values were included in these surveys: identities (related to family, nation, health, …), sociability, individual moral and social norms, environment and nature, family, work, economy, religion, politics. Science and science education were not included in these surveys, possibly because it is too complex a question, science being often (and wrongly) considered as "value free", neutral, objective.

Nevertheless, more and more researchers consider "*the re-emergence of values in science education"*, as is the title of the very interesting collective book coordinated by Corringan, Dillon and Gunstone (2007). On the first page, the authors insist on the dominant stereotypes, saying: "*How can you be doing a book on values and the science curriculum? Good science doesn't have values*." After a large interview study in U.K, Levinson and Turner (2001, p.7) wrote: "*half of all science teachers interviewed feel that their teaching of science should be 'value free', that it does not yield issues that have social or ethical implications*" (Ratcliffe 2007).

In this paper, I shall try to refute this dominant conception of 'value free' science and 'value free' science education.
The social and ethical implications of science and of science education are today largely recognized, for instance in ESD (Education for Sustainable Development) or with the introduction of SSI (Socio-Scientific Issues) when teaching science (e.g. Sadler 2004, Simonneaux 2012).

The large domain often called "Science and Society" ought to be called "Science in Society" (Levy-Leblond 1984, Stengers 2012) and I shall try to analyze further the interactions Science / Society, including values at every levels (Figure 1).

The IOSTE Mission Statement (figure 2) is pioneer in this field, not only *"Encouraging the peaceful and ethical use of S&T in the service of humankind"*, but also *"Stressing the relationship between science, technology and society"* and *"Emphasizing the cultural and human values of S&T"*, and listing several important values for all citizens: equity, cultural diversity, sustainable development, against poverty, discrimination and injustice.

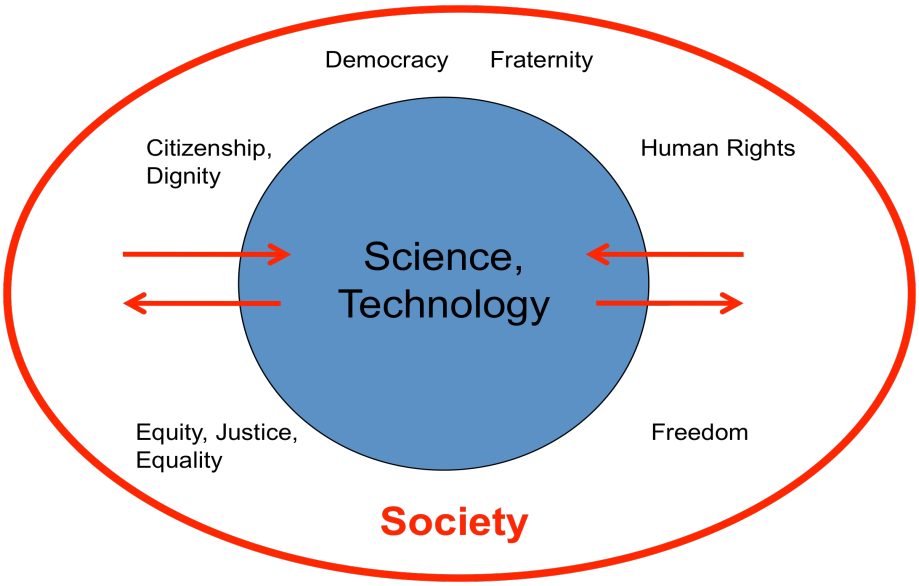

Figure 1 – *Science in Society. The values structuring the life in society (only some of them are indicated in this graph) are also pertinent for Science and Technology.*

IOSTE identifies science and technology education with the real and changing needs of humankind as a whole and with specific needs of its component communities and nations.

IOSTE considers that S&T education should:
• Highlight education for citizenship and informed, critical and active participation in democracy
• Stress the relationship between science, technology and society
• Emphasize the cultural and human values of S&T
• Promote equity in S&T and S&T education
• Promote sustainable development; contribute to the fight against poverty, discrimination and injustice
• Encourage the peaceful and ethical use of S&T in the service of humankind
• Encourage cultural diversity and international understanding through S&T education
• Stimulate international collaboration in the domains of research and development and promote cooperation with other international organizations.

Figure 2 - *IOSTE Mission Statement (from the website of IOSTE)*

The main topic of the present IOSTE Symposium (*Science & Technology Education for Development, Citizenship and Social Justice*) encourages us to analyse deeper values involved in Science Education. These correspond to three kinds of values: (1) in Science; (2) in Education ; and (3) in Science Education (Figure 3). All of them are in strong interaction with the social values of the national community.

Inside each of these domains, values are not necessarily consensual, and I will try in the last part of this paper to identify some opposite "systems of values" that are contrasted

all around the world but with strong specificities in each country, illustrating the overlapping domains of the figure 3. In conclusion, we will clarify the point that a science teacher must combine both the values of Science (to be honest, modest, etc.) and the values of Education (Education for ALL, respect of students as future citizens, etc.), as well as specific values of Science Education.

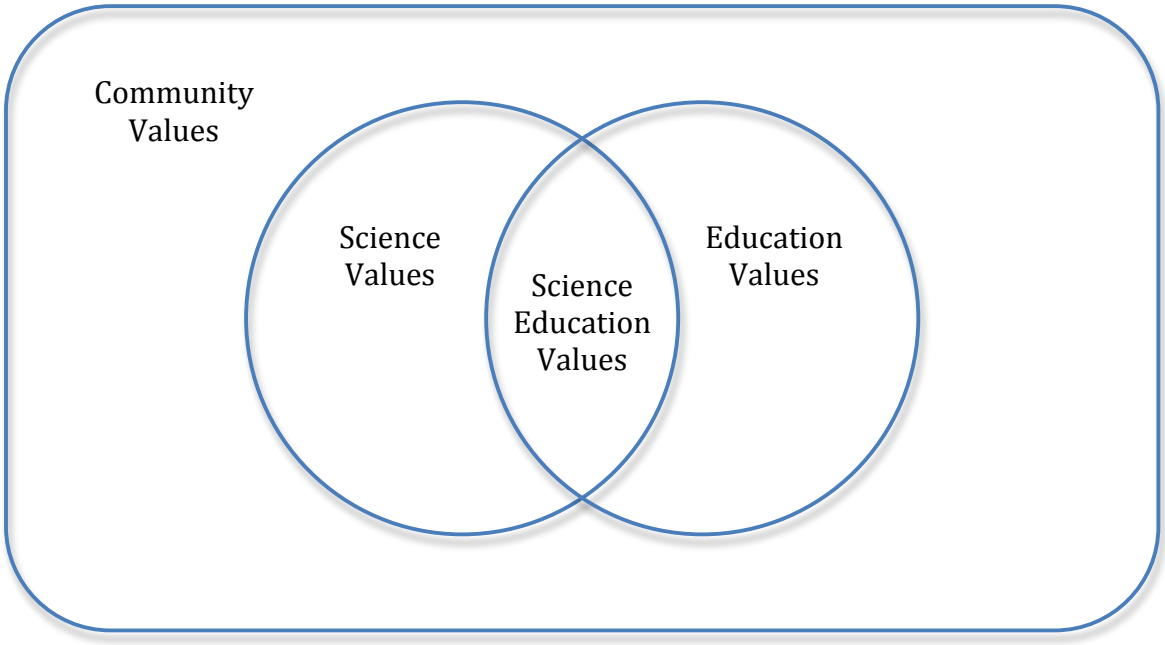

Figure 3 – *Science Education Values at the intersection between Science Values and Education Values, which are in interaction with the Social Values of the Community. (Modified from Hildebrand 2007, p.50)*

Before starting, I will try to propose **a definition of 'Values'**, because this term is not clearly defined in the growing number of works or surveys dealing with values.
We call values that which is the base of, or founds a judgement. Depending on our values, we decide if something is good or bad, important or not, right or wrong, true or false, beautiful or ugly.
My individual values are totally linked to social values, and they guide my actions, my practices, that are also social practices.
Several years ago, I proposed to better identify the possible interactions between scientific **K**nowledge, **V**alues and social **P**ractices (**the KVP model**: Clément 1998, 2004, 2006, 2010; Figure 4) to analyse the conceptions of the different actors of the educational system, as well as the conceptions underlying the curriculum or the science textbooks (figure 5).

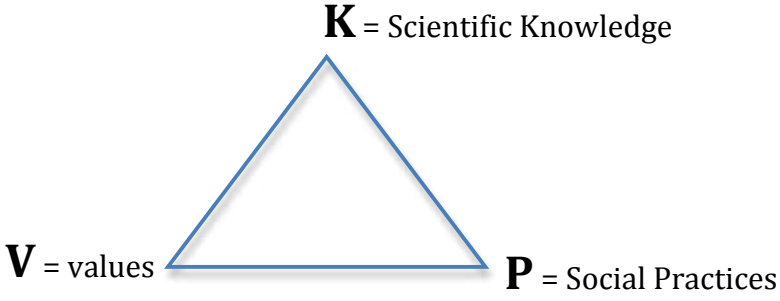

Figure 4 – *The KVP model (from Clément 2004, 2006)*

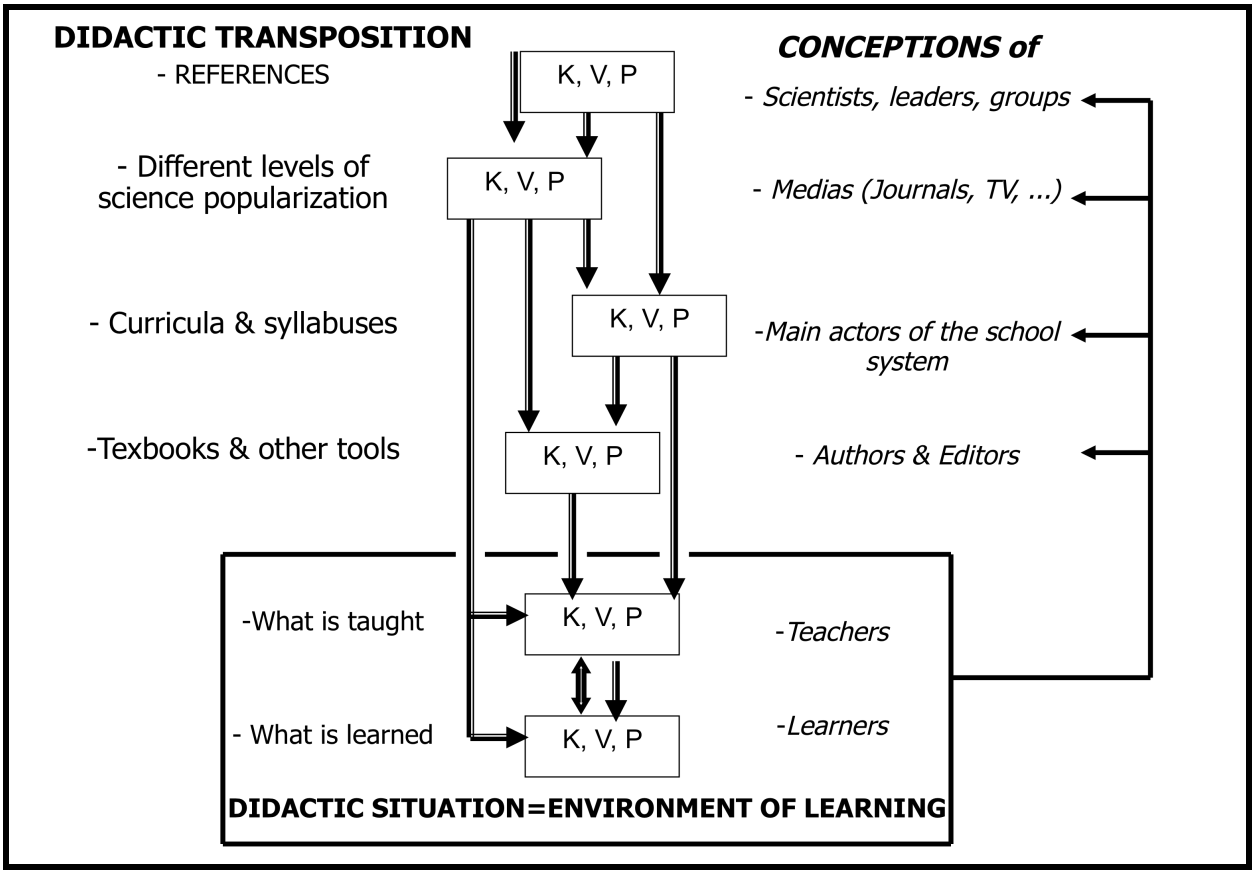

Figure 5 – *KVP (interaction between Knowledge, Values and Practices) at all the levels of the didactic transposition (modified from Clément 2006)*

2 - Values in Science

2.1 - Values of Science

There is an intrinsic link between science, technology and social values. Nevertheless, scientific research is increasingly financed because it produces results important for industry and for governance. The economical and political gains stemming from science are the first illustration of the value of science in our society. These expected gains determine the financial value of science: what research programs will be accepted, why and by whom (government for civil or military applications, firms for their profits, ...)? The financial value of research and development shows great inequality around the world. For instance, in 2010, the internal expenditures for research and development was 403 billions of dollars in North America, 348 in Asia (for the first time ahead of Europe), 304 in European Union, but only 21 in South America and 7 in Africa (From: *"Rapport 2010 de l'Observatoire des sciences et des techniques*"). Hodson (2003) said that social values underpin scientific and technological developments, but as we have just seen, economical and political power (and their values) play a decisive role.

Nevertheless, I am more interested here in the moral values of science because, while money is always necessary to do scientific research, the value of science, its degree of truth, cannot be measured only by its financing.

Science looks for the truth through demonstration, experimentation, rationality of proofs. There are several trends in the philosophy of science which analyze how it functions (for a synthesis, see for instance Chalmers 1982, 1990). As it was well shown by Popper (1972 and other works), a proposition is scientific only when it is open to refutation falsified, but is not (yet) refuted by other scientists. Science is not dogmatic and is constantly improving, developing. Most of the studies of Science Education dealing with NOS (Nature of Science) stress this specificity of scientific knowledge, and the importance of understanding and explaining how science is produced and permanently corrected and improved.
This normal functioning of science is full of values: a scientist must be honest, modest in front of the experimental results, always critical, rejecting any dogmatism and any fraud, analyzing all the possible bias, but also creative, developing his / her work with imagination and rigor, and more and more collectively.

Unhappily, the number of frauds is regularly growing in the scientific community, as has been shown in a recent publication of Fang, Steen & Casadevall (2012, Figure 6). Nevertheless, for these authors, this observed fraud concerns today only one scientific paper in 10 000, which is reassuring.

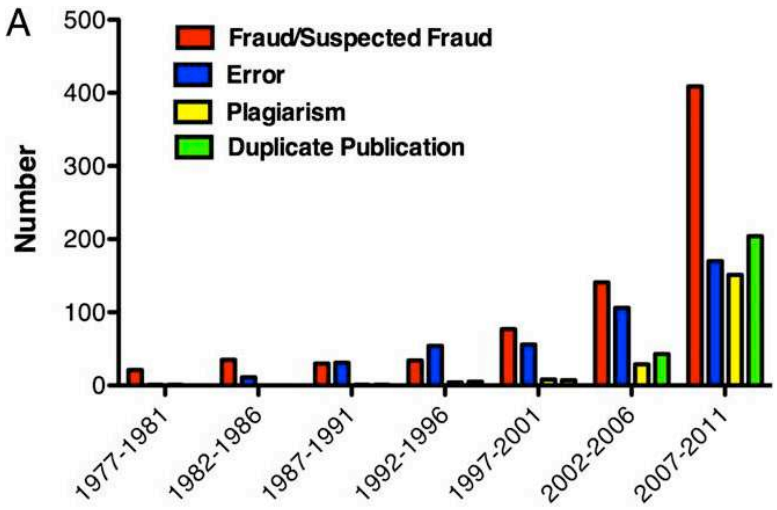

Figure 6 – *The number of declared frauds is growing in scientific publications (graph reproduced from Fang, Steen & Casadevall, 2012, PNAS)*

More important is the fact that all research scientists are human beings, as shown by the description of their everyday life in their laboratories (Clément 1969, Latour & Woolgar 1979). At the time Latour was more radically critical, characterizing scientific knowledge of 'artefacts', but his most recent book (2012) is more consensual, recognizing specificities of science.

Nevertheless, this perspective is adopted in the following paragraph, where we show that beside the main values of science, it is possible to identify other values in scientific publications, reflecting social practices often linked to the scientists' own convictions or

ideologies (possible frauds or plagiarism, shown in the figure 6, are only some practices comprising deviant facets of their ideology).

In summary of this paragraph 2.1, the **KVP interaction** in science involves important **V**alues (to be honest, modest, critical, not dogmatic, imaginative,…) linked to scientists' social **P**ractices (research work in the laboratory requires financial support, the need to publish, importance of building a reputation) which result in scientific **K**nowledge (published in Journals and not frefuted by other scientists).

2.2 – Other Values, and Ideologies, of scientists and science

Canguilhem is a recognized philosopher of biology (Canguilhem 1965). In 1981, he published an interesting book (*Ideology and rationality in the history of sciences of life*), identifying an implicit ideology inside the biological knowledge: the reductionism.

The history of genetics is an interesting example of an interaction between science and ideology. The origin of human features or performances has been often considered as the pure consequence of a *genetic program*, as a kind of predestination by God: everything happening was written in advance (Clément & Castéra, 2007; Kupiec & Sonigo, 2000; Fox Keller, 2003). Ideas of innateness were very strong during the first half of the 20th century, reaching a high point with Nazi ideology. During this period, research in genetics was growing and being structured in France into institutes of *genetics and eugenics.* More recent work — such as that of the psychologists Keller (2005) in Germany, or Dambrun, Kamiejski, Haddadi and Duarte (2009) in France — shows that, even today, differences among genres or ethnic groups are often justified by this deterministic representation of genetics, which is thus linked to ideologies such as sexism and racism. Since the late 20th century, the reductionist representation of genetic determinism —all by the genes— has declined (Atlan 1999), giving more and more importance to theories of complexity with the new paradigms of *emergence* (Stengers, 1997) and *epigenetics* (Wu & Morris, 2001). The interaction between genes and their environment (Lewontin, 2000) is now accepted by the scientific community (Clément & Castéra, in press).

In consequence, scientific **knowledg**e of genetics was historically linked to two trends of values: **(A) Values of fatalism**, with a strict genetic determinism justifying inequalities among human beings; and **(B) More citizenship values**, with an interaction between genes and environment, and consequently more equal potentialities of human being when they born.
Even today, there are different **practices of research** in genetics, functioning on the trend (A), for instance still trying to identify a genetic determinism of intelligence, or on the trend (B), working on epigenetics or showing that the main human performances come from cerebral epigenesis.
This KVP interaction is historically clear (and even today), allowing us to dress a list of biologists having the conception (A) (Burt, Eisenck, Dawkins, …) and an other list with the trend (B) (Lewontin, Rose, Kamin, Jacquard, Atlan, Stewart, Kahn, Kupiec, …).
This clarification can be useful for biology teachers when they teach some hot topics in genetics.

The same critical analysis of scientific knowledge can be performed in other scientific domains. I will take another example: neurobiology.
I made the critical analysis of a letter published in Nature in 1995 (Clément 2001)

Sex differences in the functional organization of the brain for language

Bennett A. Shaywitz*†, Sally E. Shaywitz*, Kenneth R. Pugh*‡, R. Todd Constable§, Pawel Skudlarski§, Robert K. Fulbright§, Richard A. Bronen§, Jack M. Fletcher‖, Donald P. Shankweiler‡, Leonard Katz‡ & John C. Gore§¶

The main image of this paper was reproduced on the cover of this issue of Nature (Figure 7)

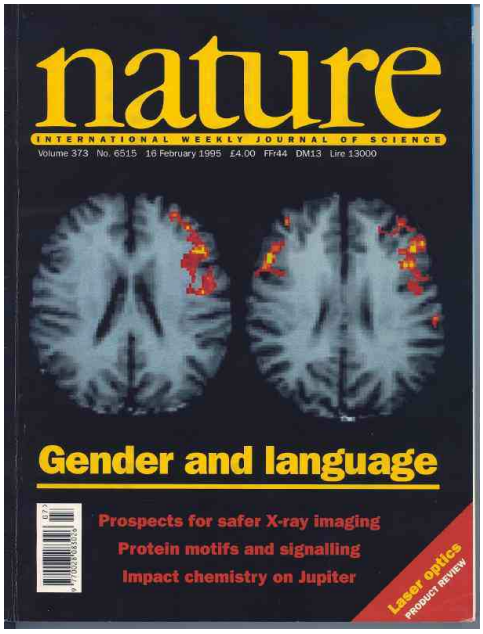

Figure 7 – *The cover of the issue of Nature volume 373, N° 6515 (1995)*

The title of this paper, as well as its main image, suggest that there is a significant difference between male and female brains concerning language, while the actual results showed no difference for three tested functions, including the semantic function, and a small difference at the limit of statistical significance for just the fourth function: rhyme of words which have no meaning. And even if some difference between male and female brains can be shown, this does not mean the difference is necessarily genetically determined. For instance, the brains of identical homozygote twins are not lateralised in the same way when one is right-handed and the other left-handed (Steinmetz et al 1995, in Changeux 2002).
We can conclude that the message of this scientific publication, and of the Journal Nature, was more ideological than scientific; but it was subsequently given wide publicity in other Journals and media (Clément 2001).

2.3 - Science, religion, ethics: what borders?

The main values of science (to be rigorous, rational, honest, critical, creative, etc., see above point 2.1) can explain how science aims as far as possible at the truth (even if the scientific knowledge is always under construction); but it is impossible to say that science is the only truth in our world. There are other categories of truth (aesthetical, emotional, social, practical, ethical, …) and claiming that only science is truth is an ideology, called scientism.

Each other category of truth has its own values, justifying our judgements, why we consider this abstract painting as beautiful or not, this love as true or not, etc.

Each religion, for instance, constructs its own system of values and system of truth. Several of these values are convergent among different religions (do not kill, do not steal, …). Consequently, we may think that there is "*a core of universal values*" which are at the basis of moral philosophy, "*defining at any moment the limits of what is unacceptable, unjustifiable, intolerable*" (Canto-Spenber, 2002, my personal translation). These "*universal values*" are at the basis of *the Universal Declaration of Human Rights,* adopted today in 191 countries all around the world[1].

These universal values also function in science, and are respected by each researcher when working. The problem of the borders between values of science and other values is nevertheless crucial, and double:

(1) Avoiding the interference inside science of values that are outside the field of science, such as religious or emotional values.
(2) Avoiding the interference of scientists in decisions or opinions that are outside the field of science (religious, ethical, affective fields).

The problem is complex.

(1) The example of Galileo is famous, showing how the Catholic Church wanted to impose its views on scientific research and scientific truth. The clear separation between science and religion is the solution, but is not yet totally accepted in several countries, even by biology teachers (as shown in my other communication in this IOSTE XV). It is still important to clarify the historical and contemporary relationships between science and religions, in several scientific domains (Maurines 2010) and particularly for Evolution (Portier, Veuille & Willaime 2011).
(2) Nevertheless, the society cannot accept a total independence of the scientific research (functioning often on public funding) and in most of countries, as well as in upper levels such as the European Community, there are Committees of Ethics and other institutions of control, with two types of functions: to accept or not some experiments as being ethical or not (e.g. when using animals or human beings); to accept or not some economical or social use of the scientific results, when they can be dangerous (nanotechnology, toxic drugs or food, GMO, assisted procreation, use of stem cells, etc.).

These last examples are interesting illustrations of KVP interactions: values can control some socio-economical practices and the use or development of scientific knowledge.

For Stephen Jay Gould (2000), a well-known biologist who is a specialist of evolution, there must be a clear distinction between Science and Religion, that he calls two NOMA (Non-Overlapping MAgisteria).
We prefer to speak about Science and Morals (including religion, but also values of non believers) and to define these two domains by their respective KVP (knowledge, values and practices): figure 8. There is an overlapping, for all bioethical questions, and for all citizenship values. Some values are specific to the domain of morals, some others to the domain of science, while some are the same for the two fields. For instance, to be honest

[1] Nevertheless, some authors consider these values as more relative to the context than universal. For instance, Ljalikova (2007), analyzing the Universal Declaration of Human Rights, considered its values as "*changing and fluctuating".*

and against any fraud was in the list of values of all scientists, but it also is a more general citizenship value.

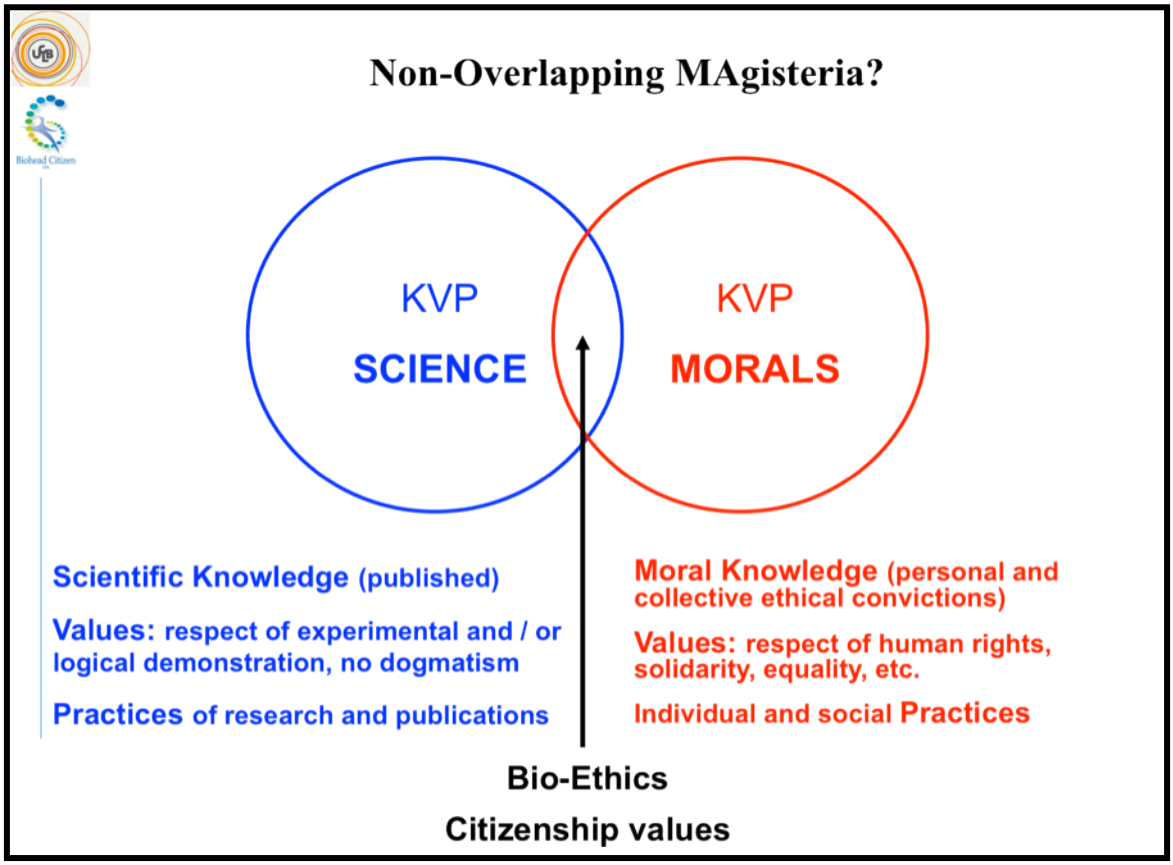

Figure 8 – *The possible overlapping of Science and Morals can be re-interpreted by analyzing the KVP dimensions of Science and Moral (from Clément et al 2009)*

3 – The values of Science Education

3.1 – Values of Education

UNESCO promotes Education for All, rooted in a fundamental value: the equality of all the human beings around the world. Nevertheless, there are still strong differences among countries, from 26.2% of literacy in Mali to 100% in Georgia, to take the extreme values of the PNUD Report 2011. The latest UNESCO Report (2012[2]) shows that the number of children out of school is no longer decreasing (61 millions in 2010 as in 2008; it was decreasing before, from 108 millions in 1999).
There are two sets of values in competition: to give priority to a high level of education for few students, or to favour basic education for all. This determines the choice of each

[2] UNESCO, Rapport mondial de suivi sur l'éducation pour tous 2012.

government, but also of international aid. For instance, the UNESCO Report (2012) points out that the price of one grant for a Nepalese student to go to University in Japan would permit to 229 children to go to secondary school in Nepal.
One more remark: the help of developed countries to students of poor countries can have a vested interest, because it can favour the brain drain: the best students often stay in US or Europe while they are a cruel loss for their country of origin.

The Four Pillars of Education, described in the Delors' Report to UNESCO: *"Learning: The Treasure Within"* (1996), are the basis of education: **1. Learning to know, 2. Learning to do, 3. Learning to live together, 4. Learning to be**. UNESCO then added a fifth pillar from ulterior works (for instance Black 1999): **5. Learning to transform oneself and society** (Clément & Caravita, 2011, p.14). Each of these pillars includes citizen values.
Most of these values are implicit, but are often more explicit when presenting the taught topic. For instance, Reiss (2007) focuses the aims of education on two points: autonomy and well-being, while he proposes more aims for science education: supply of future scientists, scientific literacy, individual benefits, democracy, social justice or socio-political action, criticality. Nevertheless, most of these points deal more with general education (and with some of the five pillars of education proposed by UNESCO) than specifically with science education alone.

In several countries, religious education is included in the curriculum, and is focused on values, with possible apparent contradictions between science and religion, for instance for teaching evolution (there are several books on this problem, e.g. Coquidé & Tirard 2008, Jones & Reiss 2007).
A contrario, in some countries such as France, religious education is proposed only outside school, with nevertheless a cultural presentation of all the religions at school. This position, called "laïcité" (a word difficult to translate in English: "secularity"?) is the contrary of the promotion of atheism or agnosticism, because it aims at developing a total respect of any religion (Baubérot 2003, 2004; Baubérot & Milot 2011). Very recently, the new French Minister of National Education decided to enrich the French school curriculum by teaching "morale laïque" (secular morality) at all levels of primary and secondary school, to try to supply a certain deficit of taught citizen values.

More generally, as shown in Figure 3, science education values include all the science values and all the education values, with possible specific values linked to science education. Analyzing the knowledge involved in education, Shulman (1987) distinguished seven categories: content knowledge (CK); curricular knowledge; pedagogical content knowledge (PCK); general pedagogical knowledge (PK); knowledge of learners and their characteristics; knowledge of educational contexts; and knowledge of educational ends, purposes, and values. He is mentioning values only in the seventh category, while we shown in the present paper that values are present in each of the seven categories, interacting with the teacher's knowledge and social practices (including pedagogical practices). Some of the Shulman's categories also correspond to the different steps of the didactic transposition (figure 5) including knowledge but also values and practices at each level.

To go further in the characterization of the values in science education, I will take an example, the Education for a Sustainable Development (ESD).
Then, as for the research scientists, I will make the comment that teachers of science are human beings, with their own ideologies that can interact with their teaching of science,

due to values that are theoretically outside the citizen values of science and of education. I will illustrate this point in two directions: firstly a critical analysis of some textbooks and secondly by an analysis of teachers' conceptions of some topics in biology.

3.2 – The example of ESD (Education for a Sustainable Development)

The goal of ESD is to develop students' competences including the five pillars of education defined by UNESCO. We recently analyzed the state of development of ESD in several countries, in a report for UNESCO (ESD and students' competences: Clément & Caravita 2011).

"*Competences are also social constructs, which are based on values and ideological assumptions (Rychen & Salganik, 2003). Defining competences is also an ethical and political assignment. A possible consequence may be that the competence oriented approach prescribes unintended or intended paradigms of the neo-liberal market and the Western community systems*." Report of the UNECE (2008, p. 37) .

The example of Environment and Sustainable Development is complex, because it deals with several domains: ecological, social and economical ones (Bruntland 1987), often involving scientific knowledge that not yet stabilized, and with differences of opinions among researchers or other experts. It involves values.

Several national curricula clearly formulate values to promote in the goals of ESD, as in Australia (figure 9). As other countries (Brazil, Colombia, …), Australia is reticent to use the terminology ESD, because the word "development" is often understood as "growth", while it is not possible for all the countries around the world to have the very high level of consumption of the U.S.

Learning objectives of EES

http://www.environment.gov.au/education/publications/sustainable-future.html

Schools implementing this vision will plan learning experiences that enable students to achieve the following learning objectives or outcomes. Some are specific to environmental education for sustainability, while others are more generic and relevant across several or all key learning areas.11

Knowledge and understandings

This includes an understanding of:

- the nature and function of ecological, social, economic and political systems and how they are interrelated;
- the natural and cultural values intrinsic to the environment;
- the impact of people on environments and how the environment shapes human activities, with particular reference to unique and distinctive Australian heritage traditions and settings;
- the ways different cultures view the importance of sacredness in the environment;
- the role of cultural, socioeconomic and political systems in environmental decision making;
- the principles of ecologically sustainable development;
- the responsibilities and benefits of environmental citizenship, including the conservation and protection of environmental values;
- the importance of respecting and conserving indigenous knowledge and cultural heritage; and
- how knowledge is uncertain and may change over time, and why we, therefore, need to exercise caution in all our interactions with the environment.

Skills and capabilities

The ability to engage in:

- explorations of the many dimensions of the environment using all of their senses;
- observations and recording of information, ideas and feelings about the environment;

- identification and assessment of environmental issues;
- critical and creative thinking about environmental challenges and opportunities;
- consideration and prediction of the consequences (social, cultural, economic and ecological) of possible courses of action;
- oral, written and graphic communication of environmental issues and solutions to others;
- cooperation and negotiation to resolve conflicts that arise over environmental issues; and
- individual and collective action to support desirable outcomes.

Attitudes and values

These are reflected in an appreciation and commitment to:

- respecting and caring for life in all its diversity;
- conserving and managing resources in ways that are fair to present and future generations;
- building democratic societies that are just, sustainable, participatory and peaceful; and
- understanding and conserving cultural heritage.

Figure 9 – *Learning objectives of EES in Australia*

In figure 9, it is interesting that the learning objectives are grouped in three categories similar to the three poles of the KVP model (figure 4).
Values are clearly present in the goals of ESD as well as in the schooling document of Australia (figure 10). Several of them correspond to values listed above for the values of science or of education. Some are more specific to EES.

The nine 'values for Australian schooling' have emerged from Australian school communities and from the National Goals for Schooling in Australia in the Twenty-First Century:

- care and compassion
- doing your best
- fair go
- freedom
- honesty and trustworthiness
- integrity
- respect
- responsibility
- understanding/tolerance/inclusion.

Source: Commonwealth of Australia 2004, Values Education, Department of Education, Science and Training, Canberra, http://www.curriculum.edu.au/values

Figure 10 - *Values for Australian schooling*

In other countries, the values implied in ESD were identified and listed by several authors. Forissier (2003) showed that all the analyzed textbooks and other books presenting Environmental Education mainly mentioned two values: respect and responsibility. Goffin (1992, 1997) listed a system of four values: STAR (Solidarity, Tolerance, Autonomy and Responsibility). More recently, Alaya called these values CARTAS (Citizenship, Autonomy, Responsibility, Altruism, Solidarity). All these values correspond to the category "ethical values" of the synthesis provided by Caravita et al. (2008) and reproduced in Figure 11.

As indicated above, and also by UNESCO (2009), most of these values of ESD also correspond to the values of Education for All, Education for Citizenship and Human Rights. They promote fundamental equality among all the human beings (independently of their gender, ethnic group, religion or sexual preferences), solidarity with the future generations, the respect of our Planet, the fight against inequalities, exclusions, poverty, … for the well-being of all (health, resources, peace).

1. Ecological: Referring to the maintenance of natural systems that require biodiversity; to the perceived quality of the environment (local and global); to the feeling of "inter-being" with the other living beings; to the acceptance of constraints for human action, population growth, etc.; to the awareness and acceptance of the planet as a limited pool of resources.

2. Aesthetic: Referring to an appreciation of beauty and harmony through our senses; to the pleasure gained by this perception; to the value assigned to beauty relative to other environmental affordances.

3. Economic: Referring to the exchange of goods and services among people and countries; to the definition of the value of resources (natural resources, labour, knowledge, technology); to the ownership of resources; to equity in the accessibility of goods; to the creation and distribution of profit; to the criteria for calculating the costs and benefits of human plans of actions.

4. Cultural: Referring to the maintenance of the attitudes and the practices of social and cultural units (traditions, habits, knowledge); to the free circulation of information; to the accepted/promoted agencies of cultural changes; to the image of science.

5. Social: Referring to the maintenance of the cohesiveness of the social environment; to the management and ruling of individual freedom and of interactions within a society; to attitudes about diversities (gender, sex, age, culture); to the evaluation of quality.

6. Political: Referring to the ways of managing, ruling and controlling the interactions between individuals and society, humans and environment; the attainment and diffusion of human rights; the rights of minorities; the participation of citizens.

7. Ethical: Referring to taking responsibility as users of resources, as consumers of affordances (goods, services, information), as citizens who vote, as living beings empowered by conscience; to equity, justice, respect, tolerance as objectives of individual and society actions.

8. Existential: Referring to the ways of conceiving and managing one's own life and private sphere in relation to the environment where one lives; to the value assigned to the quality of life, to the person, to life itself (and to the other forms of life); to the role assigned to the spiritual dimension (religious, artistic, ideological) in one's own life; to the attitudes related to risk taking, to sacrifice enduring, with happiness seeking.

Figure 11 - *Categories of values pertaining to different dimensions of human practical and intellectual activity that are relevant to Environmental Education (From Caravita et al, 2008)*

Nevertheless, while these values are consensual in all the international texts, we will see below that they are not accepted by all teachers. And scientists, like the populations, do not have the same philosophy of environment, displaying different ethics, more or less anthropocentric, ecocentric or biocentric (Theyss 1993, Larrère 1997, Forissier 2003). Wiseman & Bogner (2003) showed two main trends in conceptions related to environment: the pole "preservation" and the pole "utilization", that were also confirmed from our data of the project Biohead-Citizen[3] (Munoz et al 2009).

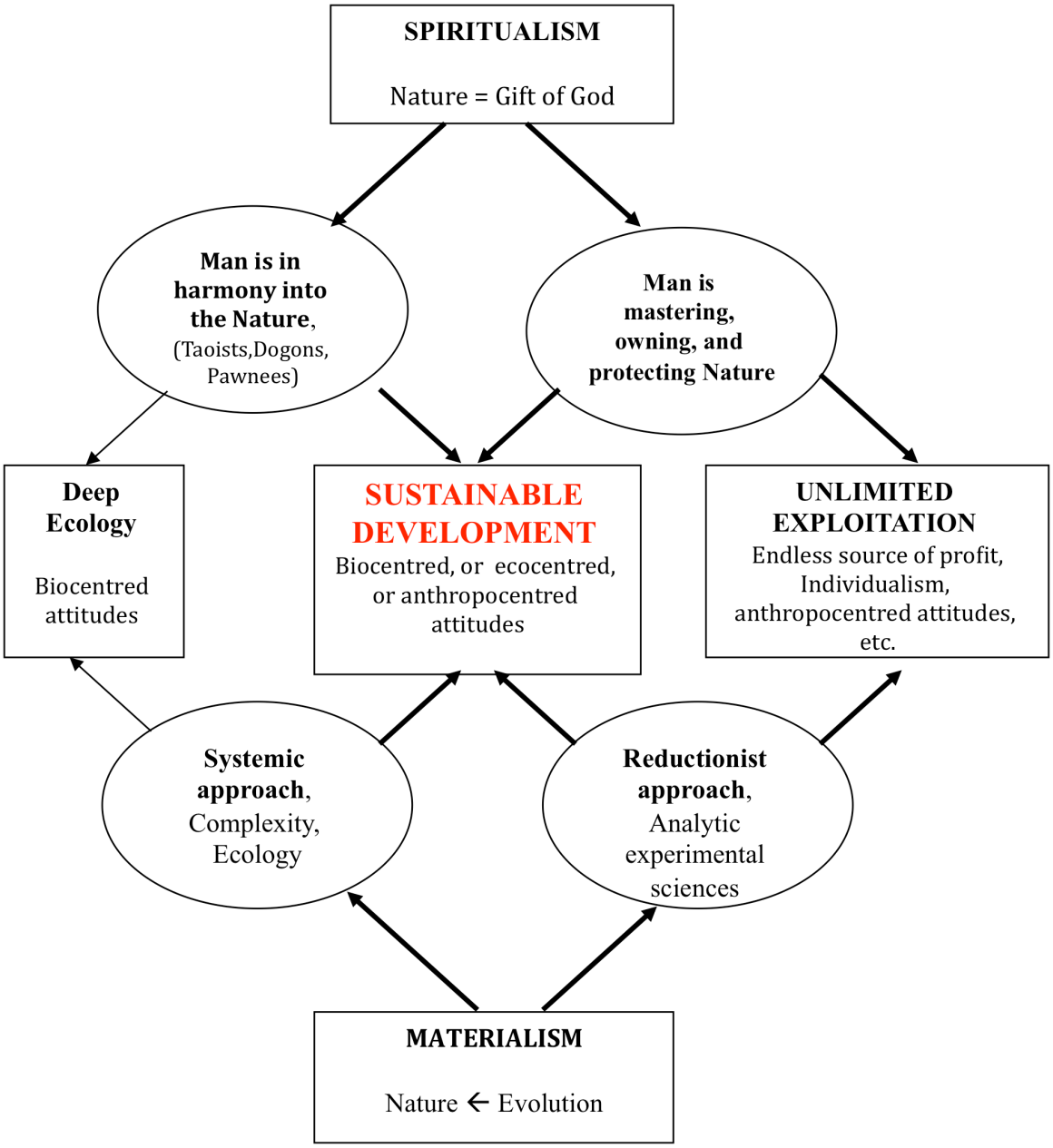

Figure 12 – *Situation of Sustainable Development related to different values and ethics of Nature and Environment (translated from Clément 2004)*

[3] Biohead-Citizen : *Biology, Health and Environmental Education for better Citizenship*, FP6 of the European Community, CIT2-CT-2004-506015, 2004-2008, coordinated by G.Carvalho, P.Clément & F.Bogner.

Figure 12 shows that Sustainable Development (SD) is clearly differentiated from two extreme of poles: one the left, biocentrism / preservation (deep ecology, preferring for instance the life of birds rather than the life of hunters); on the right anthropocentrism / utilization, with an unlimited exploitation of resources, that was clearly dominant in the industrial countries (capitalist or socialist) during the 20th century. This central position of SD can be rooted in materialist or spiritualist values. Nevertheless, inside SD it is possible to find the different ethics of nature and environment (anthropocentred, ecocentred or biocentred), with a juxtaposition of attitudes and values that can be divergent faced with environmental problems.
Our analysis of teachers' conceptions in several countries (paragraph 3.4 below) showed this divergence (Clément & Caravita 2012) and in the last part of the present paper, I will identify systems of values including those related to Environment. Before that, I will say some words on implicit values found in scientific textbooks.

3.3 - Values in biology textbooks

3.3.1 – Values linked to implicit ideologies

Let us start with an example: two textbooks of applied science for the same rural schools (Classiques Hachette publisher, 1959) for children 11-12 years old (end of primary school), with one science textbook for boys, and another for girls.

Figure 13 *– Extract of the science textbook for boys (on the left), and for girls (on the right) Classiques Hachette publisher, 1959*

When analyzing the content of the two science textbooks, half of the content is similar in both, but half is very different, dealing with different topics related to the social practices of rural men and women at this period. There is here a strong interaction between the taught scientific knowledge and social practices (KP). Figure 13 illustrates

one page specifically dedicated for boys, and one page for girls. A posteriori, more than 50 years after, this gender specialization of the scientific knowledge appears as totally sexist, as if women only had to do housekeeping and men mechanics. There is an implicit value, in interaction with the knowledge of the taught science and technology, and with the social practice, clearly illustrating the KVP model.
Today, happily, this kind of gender difference would be unacceptable in science textbooks. Nevertheless, even today, we found other images in science textbooks with implicit values linked to ideologies. I will take just two examples.

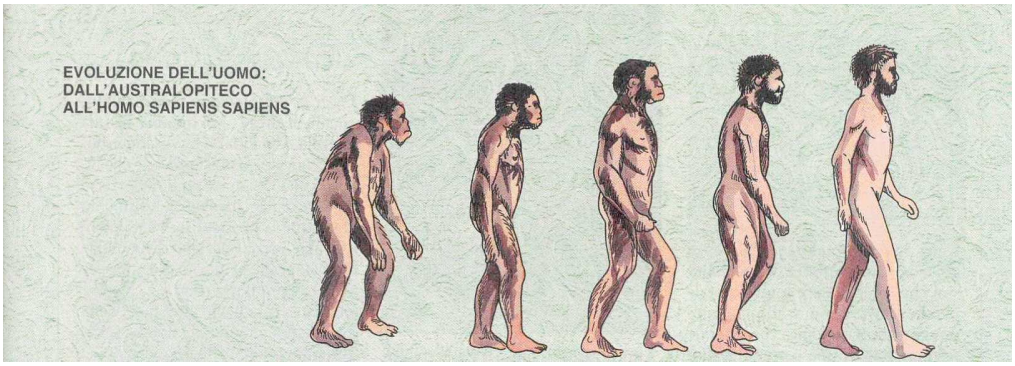

Figure 14 *– Extract of an Italian Biology textbook (Italia, Il Capitello, senior high school, 2001, p.277)*

Analyzing the topic 'human origins' in the biology textbooks of 19 countries, in the context of the Biohead-Citizen project (see above, footnote 2), we found in several countries the type of images illustrated by Figure 14 (Quessada et al., 2008). This image is scientifically wrong, because there is not a single line in the evolution of humankind, but a bush-like evolution. Nevertheless this incorrect image is regularly reproduced by the social practices of the publishers of textbooks, because it is a popular image, easy to obtain. More important, we identified implicit values in this image: the emergent *Homo sapiens* is a male, and a white one, similar to the archetype of Adam. The implicit ideologies here are sexism and Occidentalism, with a reticence to teach the African origin of our species.


Un rassemblement de jumeaux

Figure 15 - *Image of identical twins in a French textbook of biology (Belin, SVT, 5ème 2004 & 4ème 2004, for pupils 13-15 years old)*

Analyzing the topic 'human genetics' in the biology textbooks of 19 countries, here also in the context of the Biohead-Citizen project, the only images of identical twins showed them with the same morphological features (face, eyes, hair, …), that is scientifically correct and is the main function of these images: from the same genes correspond the same anatomical features. Nevertheless, each pair of twins had invariably also the same clothes, the same hair style, etc, as if these cultural features (chosen by the parents for their children) would also be determined by the genes, and that is scientifically wrong. Figure 15 illustrates one of these images, where each pair of twins is immediately identifiable from the color of their clothes.
The implicit ideology is here innatism, the belief that most of human features and performances are determined by our genes, that is out-dated today, all scientists insisting on the importance of the interaction between our genes and their environment, and no more on a kind of predestination written in our genetic program (Clément & Castéra 2007 and in press, Castéra et al. 2008).
The value underlying this ideology is fatalism: our citizen freedom is reduced if we believe that everything is written in our genes (genes taking the place of God, as developed by Kupiec & Sonigo 2000).
This strong interaction KV (scientific knowledge / Values) is also linked to social practices (illustrating here also the KVP model): the way parents dress their children when they are identical twins, and the difficulty of publishers of textbooks to find other images of identical twins, with different features (not only clothes, but also morphological traits differentiating even identical twins, as explained today by epigenetics).

3.3.2 – Values linked to the pedagogical style

More frequent, and easier to identify, are differences of pedagogical styles among different science textbooks.
Here also in the context of the Biohead-Citizen project, we collectively defined four categories of pedagogical styles within the science textbooks that were analysed: (1) only informative, (2) injunctive, (3) persuasive and (4) participant. See for instance Berthou et al 2008 for more precise definition of these four styles, and their use to analyse the topic 'environment and pollution' in French textbooks.
When using the informative and injunctive pedagogical styles, the textbooks consider children as passive, in a behaviourist conception of teaching, whereas this conception is constructivist with the 'participant' style (problems to solve, inquiries to do, etc.).
I do not develop this important point here because it is more familiar to the readers of this paper than the preceding points.

3.4 – Teachers' values

A large part of the research in the Biohead-Citizen project consisted of analyzing teachers' conceptions related to the six topics of the project (Environmental Education, Health Education, Human Reproduction and Sex Education, Evolution, Human Genetics, Human Brain). This research was then enlarged to other countries, after the end of the Biohead-Citizen project. Several publications present parts of our results. I just illustrate them, here, with unpublished data coming from 21 countries (8 of them being added after the Biohead-Citize project), from a total of 8078 teachers (Figure 16). I will then

present a more general analysis of teachers' values, taking into account other published results.

In each country, the sample is the same: 1/3 primary schools teachers (half pre-service, half in-service); 1/3 biology teachers in secondary schools (half pre-service, half in-service) and 1/3 language teachers in secondary schools (half pre-service, half in-service). The protocol for gathering data is the same in each country, totally anonymous. For more details on our methodology, see our other communication in IOSTE XV (Clément et al) and other publications (for instance Clément & Quessada 2008 or Clément 2012 for Evolution, Castéra & Clément 2012 for Human Genetics, Munoz et al 2009 or Clément & Caravita 2011 & 2012 for Environmental Education).

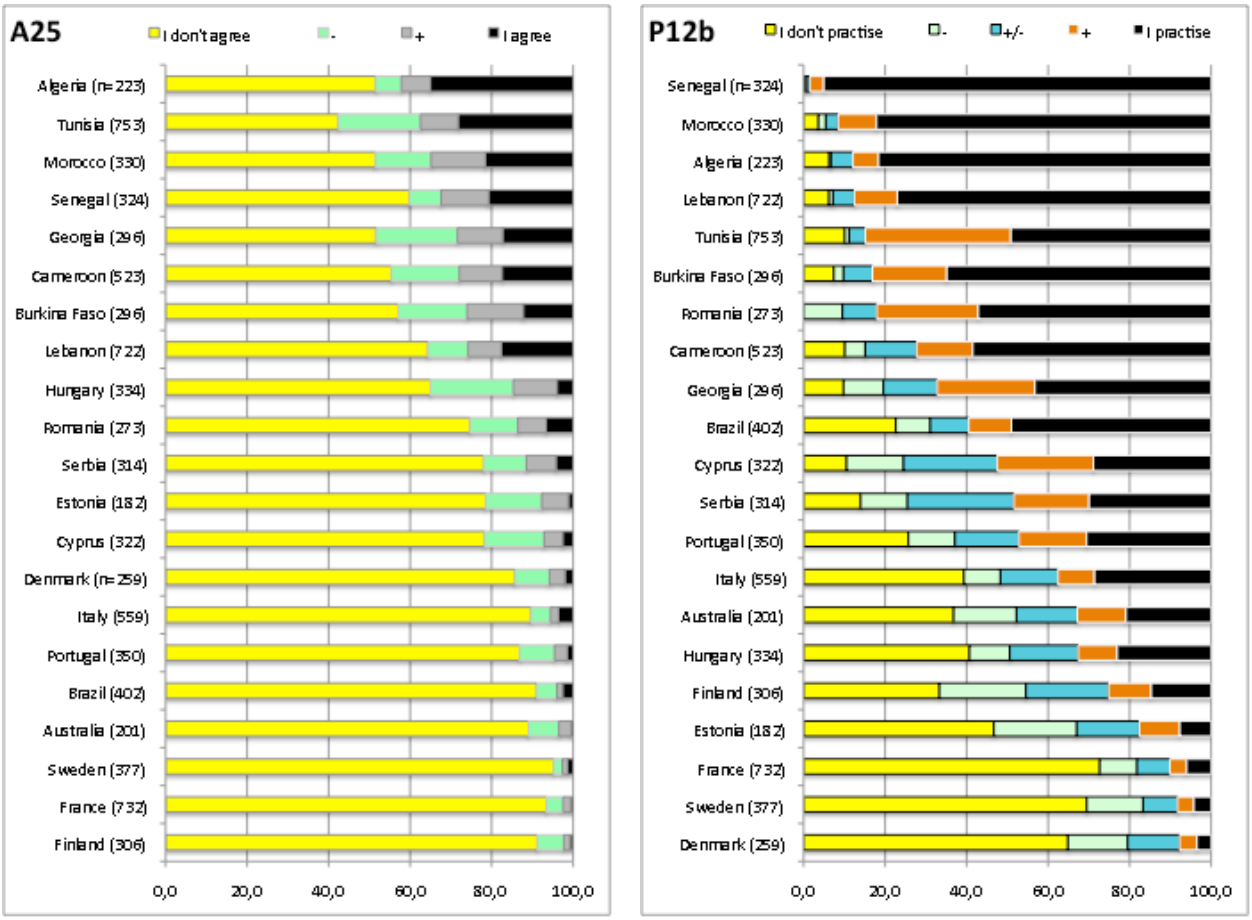

Figure 16 – *Teachers' answers to two questions of the questionnaire Biohead-Citizen. N = 8078 teachers, grouped by countries (21 countries):*
A25: "It is for biological reasons that women cannot hold positions of as high responsibility as men can." *(four boxes from* "I agree" *to* "I don't agree"*)*
P12b*: Five boxes between* "I practice religion" *to* "I do not practice religion"

Figure 16 shows, as do all our results, that there are important and very significant differences among countries. While less than 10% of teachers practice a religion (boxes 1+2 of the question P12b) in Denmark, Sweden of France, more than 90% of them practice in Senegal, Morocco or Algeria. The differences are also significant for the answers to the question A25 (explaining by biological reasons the absence of women in

high responsibility positions), and there is a significant correlation between the answers to the questions A25 and P12b, but a correlation does not automatically imply a causal relation. For instance, in Tunisia, while 85% of the interviewed teachers practice religion, 'only' 37% agree or rather agree with the proposition A25 : more than half who practices religion do not agree. It was nevertheless surprising to see that between 30% to 45% of teachers agree or rather agree with the proposition A25 in the tested African countries and also in Georgia and in Lebanon, while this 'knowledge' (a biological difference between men and women explaining that women cannot hold positions of a high responsibility) is today totally out-dated (it was defended by some biologists only at the end of 19th Century and beginning of 20th Century). The persistence of this out-dated knowledge illustrates a KVP interaction.
The correlation is very significant for the answers to the questions A25 and P12b: the more a teacher practices religion, the more he or she indicates agreement with the proposition A25. Nevertheless, there is no difference among Christian and Muslim teachers. In Tunisia, Algeria, Morocco and Senegal, all the interviewed teachers or most of them were Muslim. In Cameroon, most of them are Christian, while in Burkina it is half / half, in Lebanon 1/3 Christian, 2/3 Muslim and only 8% of interviewed teachers are Christian in Senegal. When, in the same country, there are both Muslim and Christian teachers, there is no significant difference between them.

As illustrated in another text of the present volume IOSTE XV (Clément et al.), sexism is more apparent in the answers to the question A38 (*It is for biological reasons that women more often than men take care of housekeeping*): from 5% of agreement in France to 70% in Algeria, with all the % between these two extremes and also with differences among the European countries.

More globally, we did different multivariate analyses from our data dealing with evolution, human genetics, ecology and environment. In particular we did co-inertia analyses to identify the main correlations between the answers, showing different conceptions among the interviewed teachers.
The most correlated answers were found from the following topics:

- Creationism (related to the origin of life: A64, the origin of humankind: B28, the role of God in species evolution: B48, etc.: see, for the list of all the questions, Quessdad 2008, Clément & Quessada 2009, Quessada & Clément 2012, Clément 2012)
- sexism (biological differences attempting to justify gender differences: as the questions A25 and A38 commented above)
- racism (A35: *Ethnic groups are genetically different and that is why some are superior to others*.)
- homophobia (A41: *Homosexual couples should have the same rights as heterosexual couples*.)
- anthropocentric attitudes (e.g. A16: *Our planet has unlimited natural resources)*. And other questions: see Munoz et al 2009, Clément & Caravita 2012.
- Degree of believing in God (P12a) and of practising religion (P12b, above figure 16)
- Political opinions (e.g. A42: *Only a strong central power can put some order in my country*. A37: *Religion and politics should be separated*. A51: *Science and religion should be separated*.)

From these correlations, two opposite systems of conceptions (as defined in Clément 2010) emerge, each one being characterized by a system of values:

(A) A pole with highest degree of sexism, racism, homophobia, and also the most creationism and more anthropocentric opinions, linked to a higher degree of believing in God, practising religion (figure 16), politically for a strong central power and no separation between religion and politics, as well as between science and religion.

(B) A pole with the totally inverse conceptions.

Nevertheless, the conceptions of several teachers are located between these two poles, and other oppositions of conceptions can be identified even if less structuring the data than the opposition between (A) and (B).

In conclusion, the most important here has been to point out that a value is not isolated, but generally inserted in a system of values. To improve science teaching, and the training of science teachers, it is important to identify these values, which are in interaction with social practices. Both (V & P) claim to be rooted in scientific knowledge (K) that can be out-dated (as the biological differences between men and women, evoked to justify a gender inequality).

These opposite systems of values are linked to opposite socio-political opinions and practices, themselves correlated with opposite philosophical trends: e.g. Hobbes for (A) and Rousseau for (B).

More work is to be done to analyse if these opposite systems of values are or not (and more or less) correlated with pedagogical trends: e.g. more active vs. more traditional pedagogy, or 'education for all' vs. 'education for only an elite'.

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